The monitoring of the technological equipments by the technological process specific parameters

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Abstract: - In order to establish the existence of the nonlinear character of the viscous-elastic dynamic isolation systems, practically, it is achieved by underlining the functional parameters variation that characterizes the dynamic operation behaviour of technological equipment. Thus, the functional state of the dynamic action machines and equipments is intermittent, periodical or continuously supervised until the controlled parameters modification requires the system’s repairing or stopping.

Key-Words: vibration, non-linear, linear, detect, damage, frequency

1 Introduction
The monitoring of the operating equipments and machines by the technological process specific parameters represents an efficient modality of increasing the operating safety efficiency and of decreasing the production and operating costs. The objective of the monitoring activity is to verify the functioning normality, to identify the contingent deviations and to provide the vital information’s for decisions and interventions, for disconnect or stop, for diagnostic [3].

2 Methodology of monitoring
The monitoring represents the activity of obtaining information's related to the mechanical system function, with some characteristic measuring systems and methods with the purpose of supervise and intervention for remedy. The technical systems diagnostic implies the detection of the defections appeared in operating and their causes based on the information's obtained by monitoring and control. According to the monograph, the purpose of the monitoring system is:
- preventive with automatic suspension of the operating process, if is necessary;
- analyses and diagnostic, with the identification of the state modification causes and that way predicted, with the selection of the main state modifications in development, preventing the imperfections by establishing the most efficient solutions of intervention to eliminate the damage causes.

The routine periodic or continuous measurements with the state changes identification are meant to offer by adequate decisions a high rate of machines and personnel by alarming, adjusting or stopping the activity.

Term the functioning process and equipment particularities, the monitoring activity is accomplished at a different point in time reported to the system’s durability:
- during the technological process, after the assembly, for determination of the optimal functioning values of the system’s dynamic parameters;
- during the running in for the functioning accordance checkup with the one prescribed in the system’s design stage;
- at the starting of the new machines or the repaired ones, for the immediate diagnostic of the eventual defections or damages appeared in system’s functioning;
- during the current operation, in which the most important process variable are supervised.

The data transmitted by the monitoring and control system must allow accuracy in establishing the defection nature, the appreciation of the situation gravity, the consequences and the orientation to the required remedy actions.

The characterization of the non-linear behavior of the viscous elastic systems is achieved only by evaluating the effects that they induce in the dynamic answer of a mechanical system subdued to impulsive actions [4]. Considering this, it is elaborated a methodology based on experimental determination that is able to evaluate the dynamic behavior (answer) variation in time of a vibration and shock generator equipment term the characteristics variation of the viscous elastic systems installed under the equipment’s fundament. In order to avoid the estimate errors when this methodology is applied, it demands its implementation from the moment that the viscous-elastic anti-vibration system is put into operation.
The main management activities for monitoring the technical systems vibration are presented in figure 1.

![Activities of monitoring](image)

When the equipment installed on the viscous-elastic systems is put into operation, some experimental measurements will be accomplished in order to determine the characteristic parameters of the system’s optimal parameters operation, as following:

1. The vibration kinematics parameters analysis in time (movement, velocity, acceleration) that define the dynamic action equipment “signature”. The parameters analysis in the frequency field offers the possibility of the equipment dynamic bordering term the noxiousness (the destructive potential) of the vibration produced during the operation on the round area.

2. the vibration intensity and the vibration relative intensity;

3. the dominant spectra band from the frequency representations of the vibration parameters or the shock frequency spectrum that define “the equipment’s print”;

4. the representations in the phases’ plane of the vat (or fundament) vibration in order to study the movement stability;

5. the dissipated energy determination by viscous friction – the delimited area by the hysteretic loop;

6. the interspectral analysis for the determination of the answer or transfer function for the input-output ratio;

7. the coherency function analysis that indicate with accuracy the correlation between the two input and output signals of the system;

8. the spectral power density of the vibration parameters recorded on the equipment’s vat (fundament).

In order to repeat the experimental determinations at pre-established time range with the previous described stages (1-8) passing in order to obtain the data comparative analysis allows the evaluation of the variation occurred in the operational and structural characterization of the viscous-elastic dynamic isolation systems.

3 Experimental researches

This chapter presents the result of the experimental determinations made on forging hammer (2000 kg capacity) at Workshop in IUS – Brasov, fig. 2.

![Forging hammer](image)

The measurements were made twice simultaneous on anvil block and foundation vat between are placed the viscous-elastic systems for isolating and damping generated vibration during the technological process.

3.1 The measuring devices system for the acquisition and experimental data processing

The experimental determinations of the vibration level generated by the sledge hammer were accomplished by control and identification measuring as well as by measuring the interest parameters and recording as electronic format the specific measuring data achieved in control working state conditions [5].

The device system for capture, measure, monitoring, acquisition and specific processing used during this study consist in the following devices:

- Transducers RFT with sensitivity of 0,079 C/(m/s²);
- Pre-amplifiers type 2636 - Brüel & Kjær, Danemarca;
- Acquisition board NI 9233 4-Channel, ±5 V, 50 kS/s per Channel, 24-Bit IEPE;
- Oscilloscope Velleman;
- Soft PC_Lab;
- Calculus system.
3.2 Measuring conditions
The measurements were accomplished in operating conditions in charge of the sledge hammer in mould, during a complete working cycle on a detail stamp from the running production: the signals simultaneous recordings of two transducers RTF placed on the bed plate and vat;

3.3 The results presentation and interpretation
3.3.1 The time representation of the acceleration signals
Forward it is shown the graphic representation of the acceleration recorded on the bed plate and vat, for four sets of experimentally achieved signals, based on which are determined the maximum values of the acceleration, fig. 3-6.

![Fig. 3 The signal acceleration on bed plate - first measurement](image1)

![Fig. 4 The signal acceleration on bed plate - second measurement](image2)

It is observed that the percussions distribution one towards the other is not achieved at equal time element that process is explainable by the fact that the hammer operation is made by the attendant personnel. Therefore the fundament’s impulse signals are non-periodical functions and actually consist in spike trains.

![Fig. 5 The signal acceleration on vat - first measurement](image3)

![Fig. 6 The signal acceleration on vat - second measurement](image4)

The time evolutions of the recorded accelerations show an increase in amplitude of the acceleration signal on the vat towards the one on the bed plate, a characteristic phenomenon of the non-linear elasticity systems, shown also by the theoretical analysis accomplished in the previous chapters.

The representation of the acceleration signals recorded on the vat term the time are known as the hammer signature and show a real interest because based on them it can be established the noxiousness degree of the vibration source produced and propagated during the equipment operating.

3.3.2 The representation in frequency with Fourier transform
The application of the Fourier transform to the acquisitioned acceleration signals represents an inter-spectral type analysis for underlining the mutual signal characteristics in the frequency range. Thus, for the bed plate as well as for the vat are underlined the accelerations’ frequency spectra recorded on these.
For the bed plate respectively the vat corresponding signals are represented the frequency acceleration spectra in order to show the frequency band corresponding to the maximum amplitude components (fig. 7-10).

![Figure 7](image1.png)  
**Fig. 7** Spectra representation of acceleration on the bed plate - first measurement

![Figure 8](image2.png)  
**Fig. 8** Spectra representation of acceleration on the bed plate - second measurement

![Figure 9](image3.png)  
**Fig. 9** Spectra representation of acceleration on the vat - first measurement

The frequency spectrum representation of the acceleration signals recorded on the sledge hammer vat show the shock frequency spectrum in the frequency range of (24÷30)Hz known also as the hammer signature. Although the frequency answering spectrum of the hammer is continuous, most of the shock energy developed during the technological process is carried by the spectral components in the range of (24÷30) Hz.

![Figure 10](image4.png)  
**Fig. 10** Spectra representation of acceleration on the vat - second measurement

3.3.3 The transfer function determination

The transfer function also called the frequency answering function is determined as a ratio between the spectral power density of the acceleration signal recorded on the bed plat and the spectral power density of the acceleration signal recorded on the vat. This variable characterizes the way that the mechanical system respectively the viscous–elastic anti-vibration system influence the impulse spectrum that convert into the answer spectrum, fig. 11,12.

![Figure 11](image5.png)  
**Fig. 11** The coherence function - first measurement

The graphic representation analysis of the transfer function determined for multiple experimental measurements demonstrate that the viscous-elastic type anti-vibration system show significant values in the range of frequency (10÷15) Hz and (150÷160) Hz.
The admission of new frequency ranges for which the transfer function has significant values, is a phenomenon due to the presence of the non-linear type amortization and elastic forces.

4 Conclusions

This chapter presents an experimental investigation technique of the dynamic answer of a sledge hammer based on the monitoring activities management of the system’s vibration characteristic parameters, in order to identify and quantify the non-linearity degree of the viscous-elastic systems meant for passive isolation. In order to represent and explain the received experimental data, there were used numerical filtering modern methods, this way eliminating the parasitic component of the acceleration signals. The representation of the acceleration signals recorded on the hammer’s bed plate and vat in time and frequency as well as the coherency and transfer functions representation show a non-linear behavior of the passive isolation viscous-elastic systems as follows:

- the time acceleration representation shows superior maximum values recorded on the vat towards the bed plate;
- the frequency representation of the acceleration signals show supra-harmonically components appearance, a specific phenomenon for the presence of the non-linear behavior of the dynamic isolation systems;
- the signal transfer from the bed plate to the fundament is done on an extended domain of spectral components, contrary to the linear case for which the transfer domain is well defined.

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